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インターネットを利用した地理情報サーバの構造と構築

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ネットワークを利用した地理情報の発信は研究者・開発者にとって重要なものとなってきた．本論文では，Webのクライアント・サーバー環境の中でGISとRDBMSを統合した地理情報サーバーについて述べる．本システムは低価格のパーソナルコンピュータ上で，ソースが公開されている無料のソフトウェアを主要な部分に用いて開発した．地理情報サーバーは，RDBMSモジュール・データ解析モジュール・可視化モジュールの3つから構成される．本システムはネットワーク上でデータの収集・解析，空間情報の可視化が行える．このことにより，研究グループや一般などのより広範囲の利用者が効果的かつ高速に空間情報を構築・共有することが可能となる．

Development of an Internet based Geographic Information Server

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Abstract

Serving geographic information over a network has come to be important in various research and development activities. In the present paper, we describe the salient features of a Geographic Information Server that was developed by integrating a GIS and RDBMS in a Web based client/server environment. The system was implemented on a low-cost personal computer and a major part of the software components used in the system are open source and available free of cost. The Geographic Information Server consists of three main components namely RDBMS module, data analysis module and visualization module. The system's ability to gather spatial data over the network can be effectively utilized in situations that demand collective participation from a large number of users. Further, the system will also allow easy and speedy sharing of geographic information amongst specialist groups and/or general public.

Introduction

Geo-referenced digital maps are commonly referred to as '*spatial*' information since they represent some attribute pertaining to a known location in space. The location in space is denoted by geographical coordinate e.g. latitude and longitude. In the recent years, serving spatial information over a network has become increasingly important in several research and development projects. However, building a spatial database is a laborious task and spatial data accumulation is invariably time consuming. Another aspect that needs to be considered in the case spatial data management is regarding its access. On one hand, data needs to be made available to a selected audience who may be directly associated with the work or project. On the other hand, spatial information may also need to be made available to the general public.

As a stand-alone software tool, GIS (Geographic Information System) have come to be a very useful for managing and analyzing spatial data. However, GIS does not provide easy and speedy access to spatial data that is desirable for many applications. In recent years, Internet technology has evolved into a powerful tool that can be used as a means for gathering data and as a media for communicating graphical information. As computer networks proliferate, the possibility of providing online access to spatial data becomes all the more possible. Consequently, several attempts to implement an "Online GIS" have been initiated (e.g. Plewe, Raghavan *et. al*, 1998). Providing access to GIS and Relational Data Base Management System (RDBMS) through the Internet would offers an integrated environment wherein spatial data can be gathered, visualized, analyzed and shared. In this paper we describe a Geographic Information Server that was developed by integrating a general purpose GIS and RDBMS into a Web based client/server environment. The salient features of the Geographic Information Server are described and the utility of the system for providing online access to spatial data is discussed.

System Requirement

The system was implemented on a general-purpose personal computer with no specialized hardware requirement. The general flow and components of the system is shown in Figure 1. The system was developed under Linux operating system but can be easily implemented on other versions of UNIX. The basic components include a GIS and a RDBMS. The Apache Web Server was used for integrating the GIS and RDBMS into a Web based client/server environment. The details about the software infrastructure are listed below;

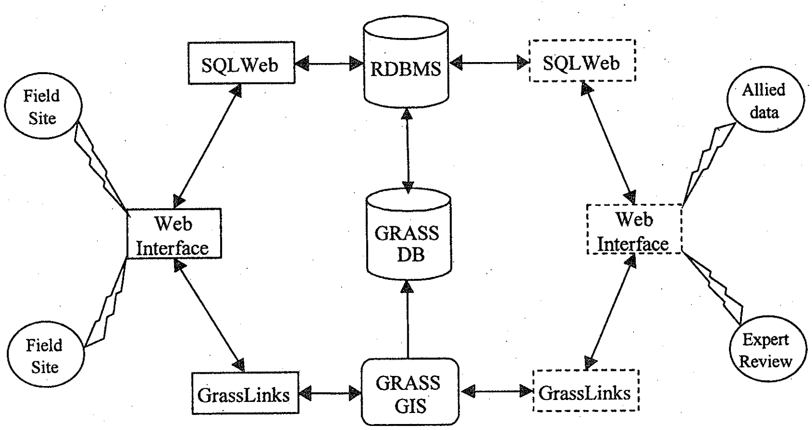


Figure 1: General layout and flow of the Geographic Information Server

GIS and Web Interface

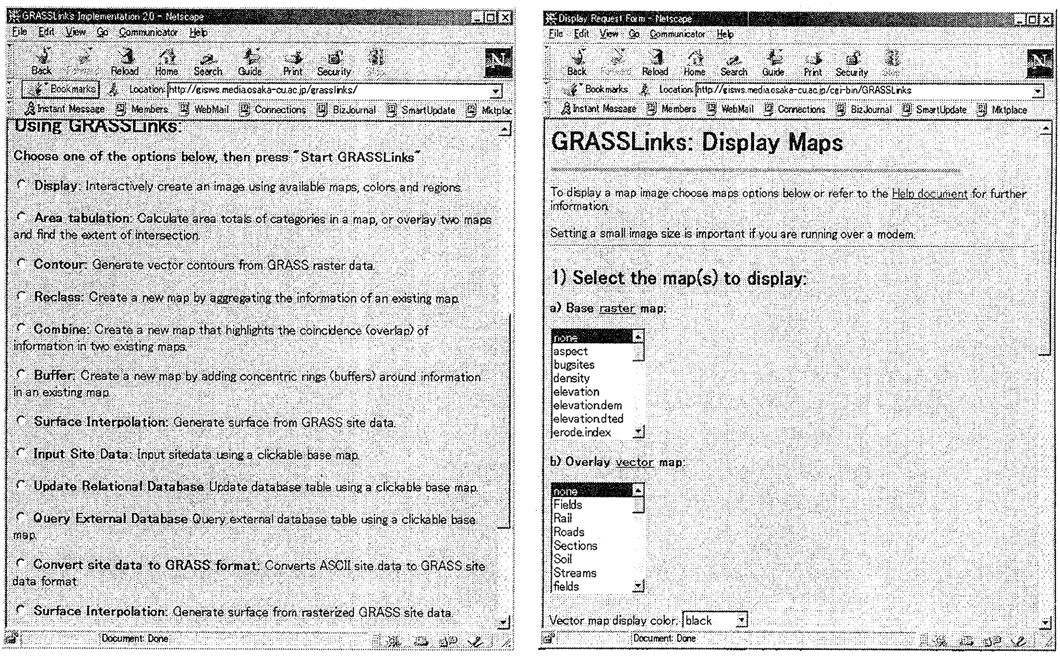
GRASS (Geographic Resource Analysis Support System; US Army Corp of Engineers, 1993) GIS was used provides the core component for visualization, analysis and management of spatial data sets. The GRASSLinks (Huse, 1995) interface was used to provide online access to the GRASS GIS functions via the Web. GRASSLinks interface consists of a set of Unix Shell scripts. Since a majority of GRASS commands can be executed in the command mode, it is quite easy to enhance the GRASSLinks interface to provide added functionality. In the Geographical Information Server, several additional modules were incorporated into the GRASSLinks web interface to tailor the system for its present needs.

RDBMS and Web Interface

In the present system, the JustLogic RDBMS (Butzen and Forbes, 1997) was used. However, other standard RDBMS packages (e.g. Oracle, Informix, Sybase, mSQL etc.) can also be used to serve as the database engine. The front-end for online access to the RDBMS was coded using the SQLWeb (Applied Information Technologies Inc, 1995). The SQLweb is an easy to use Web-SQL tool that enables the user to embed SQL statements into a simple HTML file. SQLweb utilizes the Common Gateway Interface (CGI) to interpret regular HTML markup tags plus SQLweb-specific tags and delivers a dynamic exchange between RDBMS and the client's web browser.

Client Requirements

The minimum requirement on the client's side is the ability to access a remote server using a general-purpose WWW browser (e.g. Netscape, Internet Explorer etc.). The creation, retrieval and analysis of spatial data can be done quite easily even by a first time user who have little or no experience in GIS or RDBMS. Figure 2a and 2b shows the screen shots of some of the system's options that are accessible via the Web.



a) Systems opening menu. b)Options of for image display

Figure 2: Screen shot showing various options that are accessible over the web.

System features

The system's features can be broadly divided into three modules that are described under separate heads as below;

RDBMS Module: Figure 3 shows the flow and operations involved in this module. The RDBMS module consists of an interactive Web interface wherein the user can select a base map to be displayed on the web browser. Spatial location can be input clicking at the appropriate point on this base map. SQL queries are directed to the RDBMS using this "*clickable*" (imagemap, see http://hoohoo.ncsa.uiuc.edu/docs/tutorials/imagemapping.html) base map to input the spatial coordinates. If location coordinates can be determined more accurately using a Global Positioning System (GPS), the user can directly input the spatial coordinates obtained from the GPS. Incorporation of a real-time GPS interface is being considered as a future enhancement to the system. Similarly, the RDBMS tables can be remotely updated using the attribute information and the corresponding spatial coordinates that are input from the client's browser. The location and attribute information that are stored in RDBMS table can be exported as GIS site files to enable further spatial analysis. Figures 4a and 4b shows screen shot of the data upload and retrieval interface.

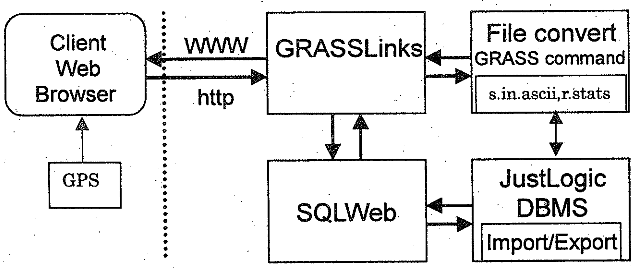
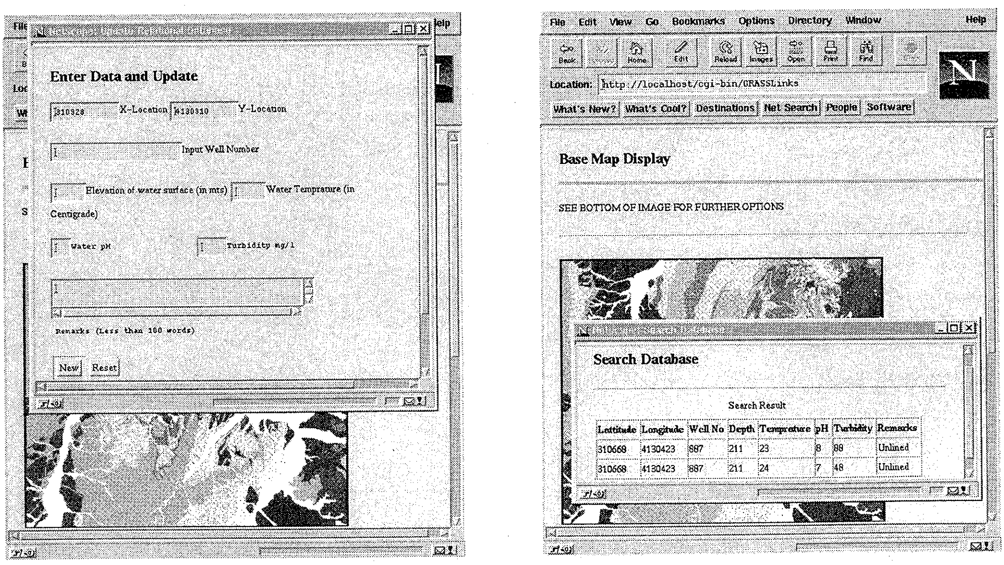


Figure 3. Flowchart of the RDBMS module.



a) Uploading data into the RDBMS b)Retrieval data from the RDBMS

Figure 4: Screen shot of data upload/retrieval interface

Data Analysis Module: This module incorporates several analytical functions available in the GRASS GIS. The flow and operations involved in this module are shown in Figure 5. The client inputs the program options browser that are interpreted by GRASSLinks CGI program. The interpreted results are stored as script files that are redirected as input to appropriate GRASS commands. Consequently, the output of GRASS command output is redirected back to the client browser as map or tables. Various tools incorporated into this module are listed below items;

- Data the exchange between RDBMS and GRASS GIS.
- Generation of interpolated surface from GRASS site data or raster site map layer. Figure 7a shows the surface interpolated from a site data file, the overlaid contours were generated using the next function.
- Generation of vector contours from raster maps. For example, contour maps showing surface distribution can be created from the GRASS site file (Figure 7a).
- Reclassification of raster map layers based on user-defined rules. This allows the client to create a new map from an existing one by combining categories from the chosen map into one new category.
- Calculation of area totals of categories in a map.
- Creation of a new map that highlights the coincidence of information in two existing maps.
- Generation of Buffer (proximity) zones depicting distances from line or point features.

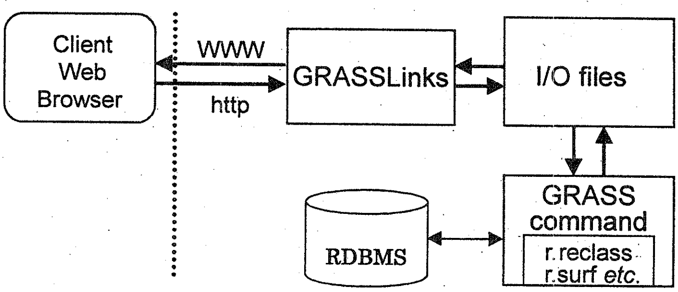


Figure 5. Flowchart of the data analysis module.

Visualization Module: This module consists of tools for 2-D and 3-D display of spatial information. The basic flow of this module is shown in Figure 6. The capabilities of this module are listed below;

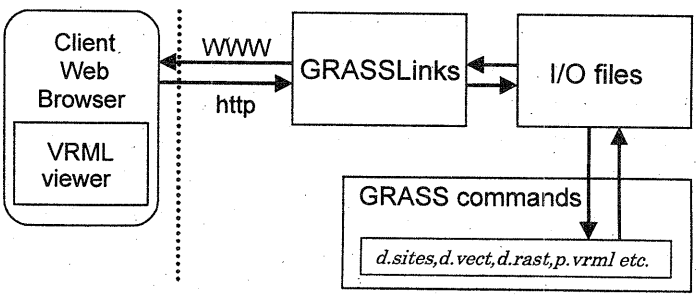
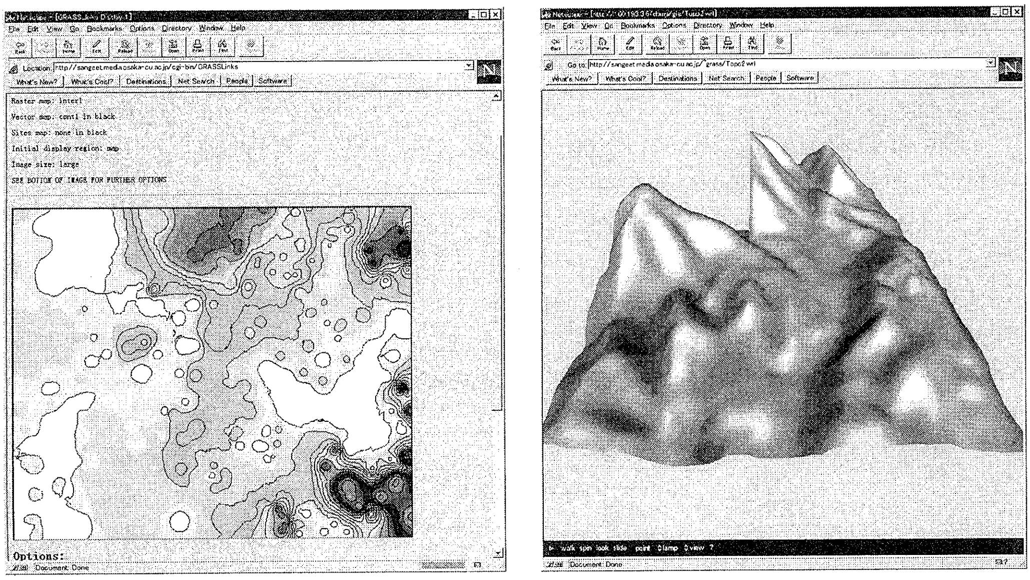


Figure 6. Flow chart of the visualization module.

- An interactive display tool for displaying 2-D images from available maps in the GIS database. The images that can be overlaid with vector (Figure 7a) and site information. In order to display the image on the browser the maps are first converted to the Portable Pixel Map (PPM) format. The PPM file is subsequently converted to WWW-readable format (e.g. GIF). The display option also includes interactive pan/zoom and map-query capabilities. The user can also isolate the displayed image and generate hardcopy prints.



a) Display of raster and vector information   b) Display of VRML model

Figure 7: Example showing 2D and 3D data visualization

- An interactive tool for generation and visualization of 3-D models based on the Virtual Reality Modeling Language (VRML). For example, draping the elevation data with a raster images can generate the VRML files. Visualization of VRML models can be done by incorporating appropriate viewer for the WWW browser (e.g. Cosmoplayer, VRWeb etc.). Figure 7b shows the VRML model that was generated by draping the DEM with the shaded relief map.

The system's features described above can be useful in a situation that calls for gathering and sharing of spatial data among a wide audience or in a collaborative project among a select user group. The various steps that may be followed in an actual situation are briefly listed below;

Step 1: Incorporation of base maps into the GIS database by digitization or scanning.

Step 2: Design of RDBMS database structure and implementation of appropriate Web interface

Step 3: Determining the extent of participation in the spatial data collection and introduction of appropriate database and network security measures.

Step 4: Development of spatial database by collective user response.

Step 5: On-line review and update of database.

Step 6: Analysis of data and generation of new maps that depict the analytical results.

Step 7: Review of analyzed maps by expert group and collective decision making.

Step 8: Communication of results to the targeted users.

The various steps described above can be appropriately reorganized or repeated to suit particular technical and geographical requirements.

Conclusion

The Geographic Information Server described in the present paper affords easy and rapid collection, analysis and dissemination of spatial information via the Internet and can therefore serve as a useful online data management and decision support tool in several applications. The system is cost-effective since it can be implemented on any low-cost personal computer and the software components are available free of cost. The system is easy to use since the user need only have a WWW browser and access to the network web server. As specific examples of its utility, the authors (Raghavan et. al, 1998, 1999) have earlier demonstrated the system's applicability in disaster mitigation and geological applications. The Geographic Information Server would be particularly useful in any scenario that requires rapid collection and sharing of spatial data among various users. Collection and dissemination of spatial data pertaining to the natural environment or other socioeconomic attributes can be considered as one such typical situation where the Geographic Information Server could be put to effective use. For example, the system's ability to generate data, analyze and visualize spatial information over a network can be useful in providing value added information to planners, scientists and the general public. Further, the system could enhance interagency collaboration in environmental and socioeconomic surveys and would vastly increase openness and participation in decision making. In order to cater to the increasing demand for the geographic information, it is highly desirable that spatial data management should evolve from a stand-alone to online environment. The Geographic Information Server described in this paper offers a tool to achieve that objective.

Acknowledgments

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